# BalPure™

## Electrolytic Ballast Water Treatment System

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# Company Background

| | |
|---|---|
| Diamond Shamrock Corporation - Electrolytic Systems Division SANILEC & Chemicals | 1974 |
| Acquisition of OMNIPURE from Sigma Chapman Engineering | 1986 |
| Formation of ELTECH International Corp. | 1987 |
| Move to Sugar Land, Texas OMNIPURE, SANILEC & Chemicals | |
| Formation of Exceltec International Corporation | 1997 |
| Acquired by Severn Trent Services | 1998 |
| Formation of Severn Trent De Nora | 2001 |

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# Experience

- Installed Base of SANILEC systems producing over 1 million pounds per day of chlorine equivalent worldwide
- Severn Trent DeNora accounts for 65% of the worldwide operating on-site hypochlorite capacity
- Over 400 systems operating in 59 countries
- Offshore applications 21 different size systems capable of producing from 3 to 2400 pounds per day of hypochlorite

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## *Ballast Water Exchange / Treatment Motivation*

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## IMO Proposed Standards

- <10 Viable Organisms per M^3 > 50u
- <10 Viable Organisms per mL<50u
- Toxicogenic Vibrio Chlorea < 1 colony per 100mL
- Escherichia coli < 250 colony/100 mL
- Intestinal Enterococci < 100 colony/100 mL

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# Ballast Water Laws

## BWT Time Line

- 2014: All vessels must have BWT per IMO
- 2009: BWT required on new vessels per IMO
- 2007: Construction of new vessels begins
- July 2007:  Washington State requires BWT
- 2006: Naval Architects need approved BWT Systems
- 2005: Ballast Water Exchange is acceptable

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# Ballast Water Exchange Drawbacks

- Exchanging ballast is dangerous while underway, heavy weather increases the danger to the integrity of the vessel
- Ballast exchange increases wear and tear on ballast pumps, valves and associated equipment
- Ballast exchange adds extra man hours for monitoring and operating equipment
- Ballast exchange adds to the chances of delaying the vessel.

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# HEAVY WEATHER

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## *How Does It Work ?*

Chemistry of electrolyzing sodium chloride

$$NaCl + H_2O + 2e^- \longrightarrow NaOCl + H_2$$

**Salt+Water+Energy = Hypochlorite+Hydrogen**

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## *How Does It Work ?*

- Seawater slip stream enters one end of the electrolytic cell
- DC electric current is passed through the Seawater
  - Free chlorine produced at the anode
  - Hydroxide produced at the cathode
- Br (Bromine) in Seawater reacts with the Hypo to form HOBr (Hypobromite)
- HOBr (Hyobromite) acts as an aggressive disinfectant when injected back into the main ballast line

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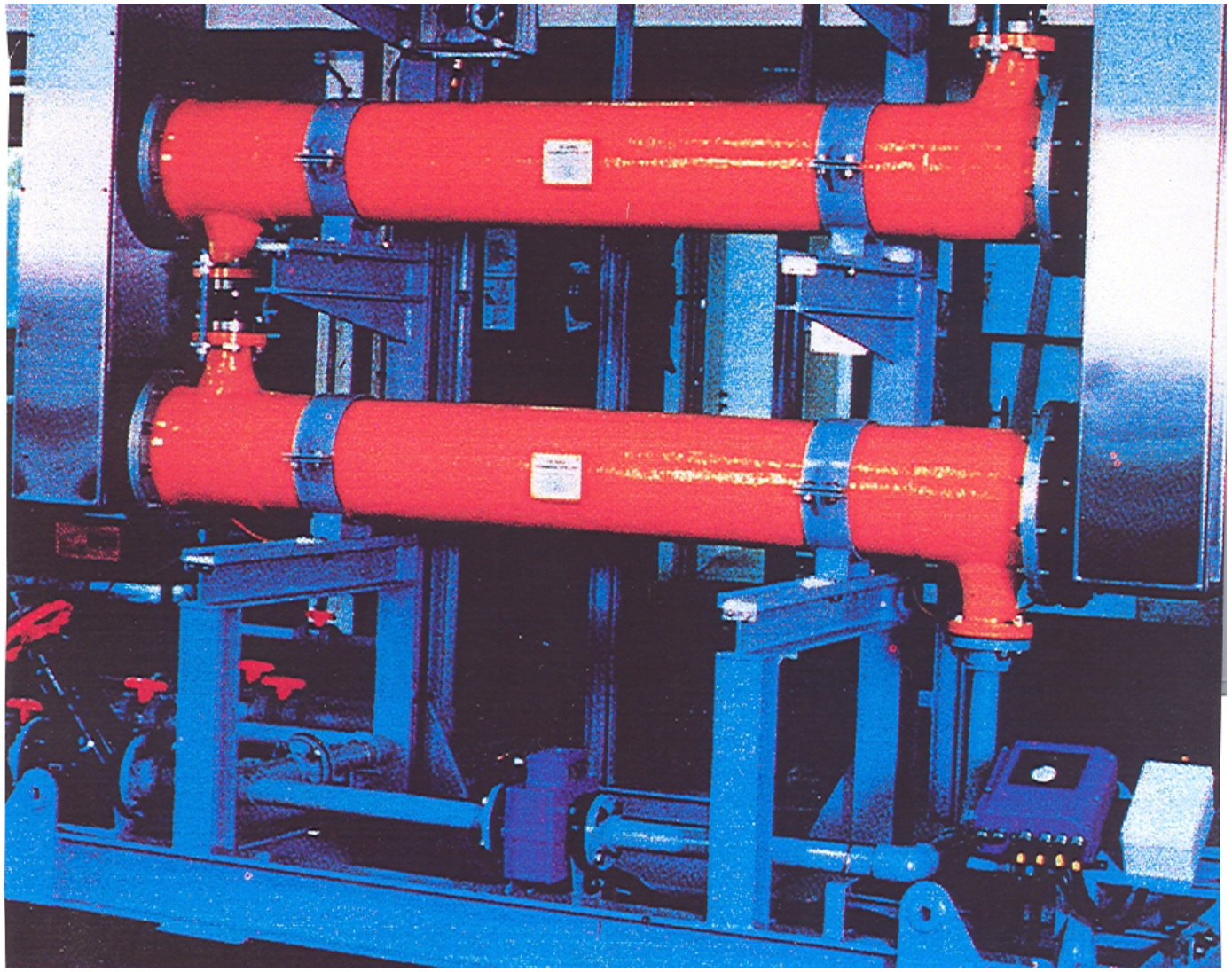
# Electrolytic Ballast Water Treatment



*Typical Severn Trent DeNora Double Cell Generating Skid*

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# Competitive Advantages

- Efficacy of Chlorine for disinfection is well established
- EC is a well proven technology with 20 years experience in the offshore industry, marine, and coastal power plants
- STDN units are modular in construction and can be backfitted into existing vessels without major modifications
- Competing technologies such as UV, ozone, filtration and bulk chemical addition are still generally unproven for economical use in the Marine Environment
- EC systems are low cost vs. the alternate proposed technologies
- The cost of EC is appx. $0.02 per M3 of ballast water treated ($0.15/KWH generation cost)

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# Electrolytic Ballast Water Treatment

## INITIAL STDN BWT System Concept

- **Filtration** to 50 microns
  - Removes Large Marine Organisms
  - Minimize Chlorine demand
- **Electro-chlorination** of incoming water with chlorine monitoring and control
  - Kills Bacteria and Smaller Marine Organisms
- **Oxidant Neutralization** at ballast water discharge with sulfite monitoring and control
  - Protects the Marine Environment
- **Data logging for verification**

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# Electrolytic Ballast Water Treatment

## *Oxidant Neutralization*

- Use sodium sulfite
  - – Also use as food, wine preservative
- $Na_2SO_3 + Cl_2 + H_2O \rightarrow Na_2SO_4 + 2HCl$
- 4 gpl $Na_2SO_4$ already exists in seawater
- HCl will not increase pH in highly buffered seawater

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# Proving the Technology

- In order to successfully market our technology, we decided to do the following :
  - Identify the region where the need for a ballast water treatment system is the greatest
  - Identify the regulatory mechanism that is in place in that market
  - Identify the method of testing that is acceptable to the regulatory agencies and ship owners involved
  - Set up a pilot test program that if successful will lead to actual shipboard applications.
- All of the above conditions are present in the State of Washington at the present time. Working with the University of Washington and the Washington State Department of Wildlife and Fisheries, we initiated a Pilot Testing program.

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## Reasons for Pilot Testing

- Accumulate data for Washington State approvals
- Accumulate data for STEP application/approval
- Optimize STDN BWT System
- Obtain Third Party Verification

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# Electrolytic Ballast Water Treatment

## *Research Study Test Objectives*

- Is 50 micrometer filtration system required and what is efficacy
- Evaluate efficacy of electrolytic generator
- Evaluate efficacy of sequential treatment (filtration followed by electrolytic generation)
- Determine effects of sulfite addition
- Characterize DBP and minimize
- Determine effluent toxicity and minimize any adverse effects

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# Phases 1 - 3

## *Test Results*

- With or without filtration:  When initial hypo concentration is at least 3.0ppm
  - Culturable Bacteria reduced >99.99%
  - Phytoplankton reduced > 99%
  - Mesozooplankton reduced > 99%
- Filtration only impacts efficacy when hypo concentration is less than 1.5 ppm
- At 1.5 ppm hypo concentration bacteria grow back within 24 hours
- TRO declines at similar rates for filtered vs. non-filtered chlorinated water

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# Oxidant Neutralization

***Test Results***

- Ballast water has no toxicity once neutralized with sodium sulfite
  - Addition of sodium sulfite does not affect zooplankton and phytoplankton
  - DBP at 3.5 ppm hypo concentration with and without sulfite meet drinking water standards
    - THM 68 ppb  (80 ppb)
    - HAA5 9 ppb  (60 ppb)
    - Bromate <1 ppb  (10 ppb)

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# Nautilus Toxicity Test

## *Test Results*

| Sulfite Added ppm | Sulfite Residual ppm | Herring Embryo (% hatch) | Menidia 7-day survival (%) |
|---|---|---|---|
| Control | 0 | 80 | 98 |
| 2.75 | 2 | 65 | 100 |
| 5.5 | 4 | 83 | 98 |
| 11 | 8 | 75 | 100 |
| 22 | 16 | 84 | 100 |

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# Nautilus Toxicity Test

## *Test Results*

| Sulfite Added ppm | Sulfite Residual ppm | Mysid 7-day survival (%) | Bivalve survival (%) |
|---|---|---|---|
| Control | 0 | 90 | 57 |
| 2.75 | 2 | 100 | 57 |
| 5.5 | 4 | 85 | 65 |
| 11 | 8 | 89 | 57 |
| 22 | 16 | 90 | 59 |

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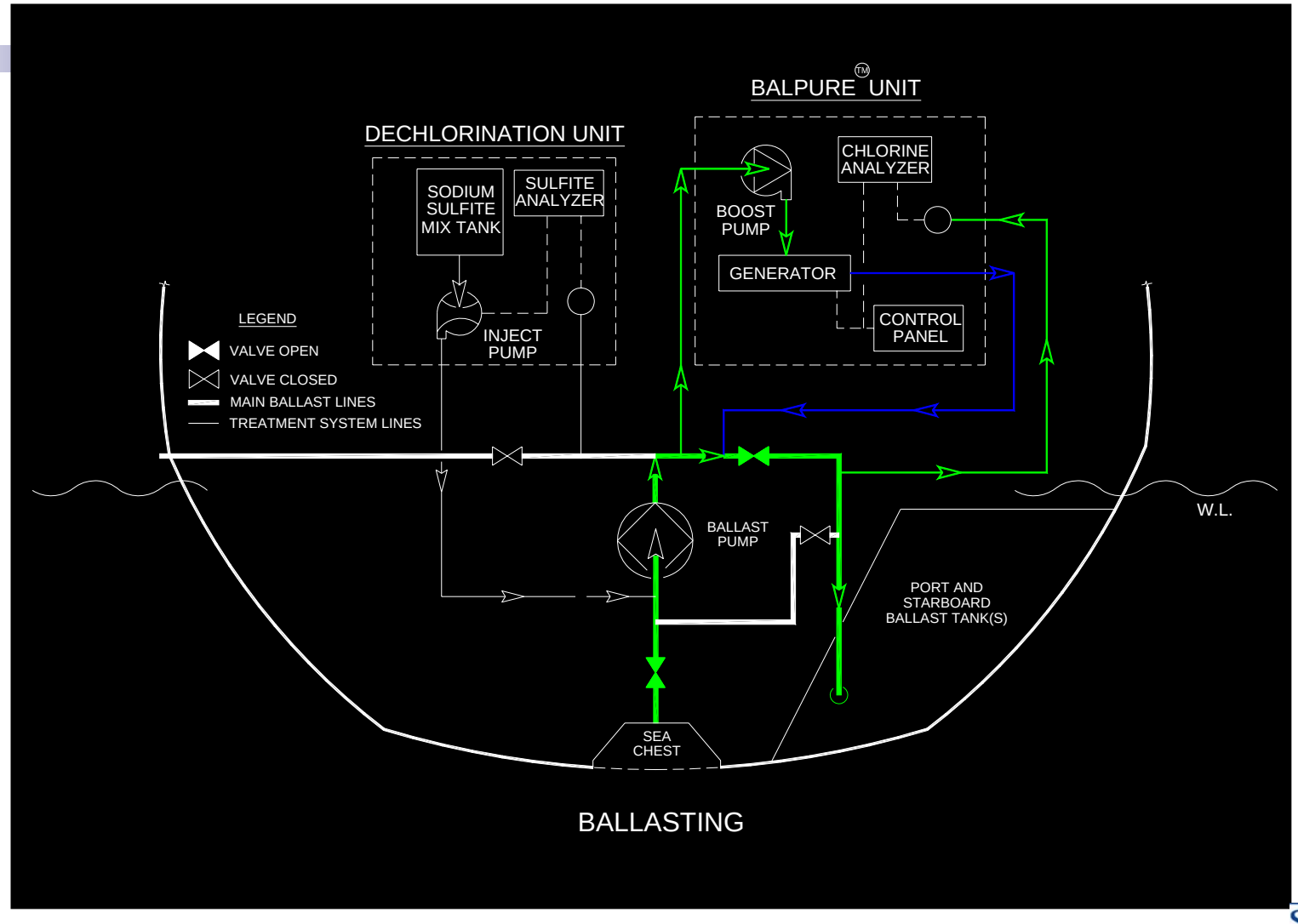


***Metered Disinfection While Ballasting***

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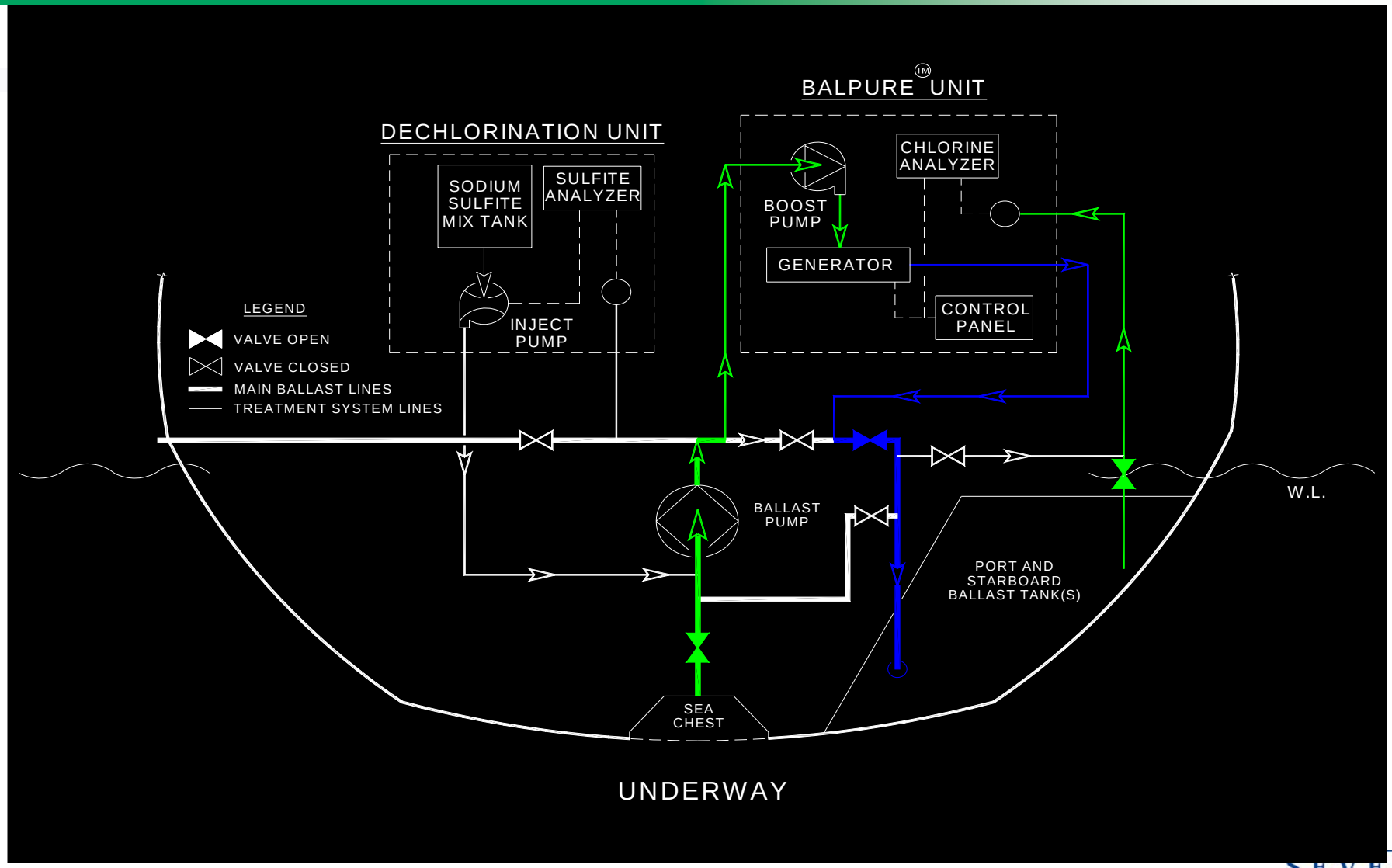


***Sampling while Underway***

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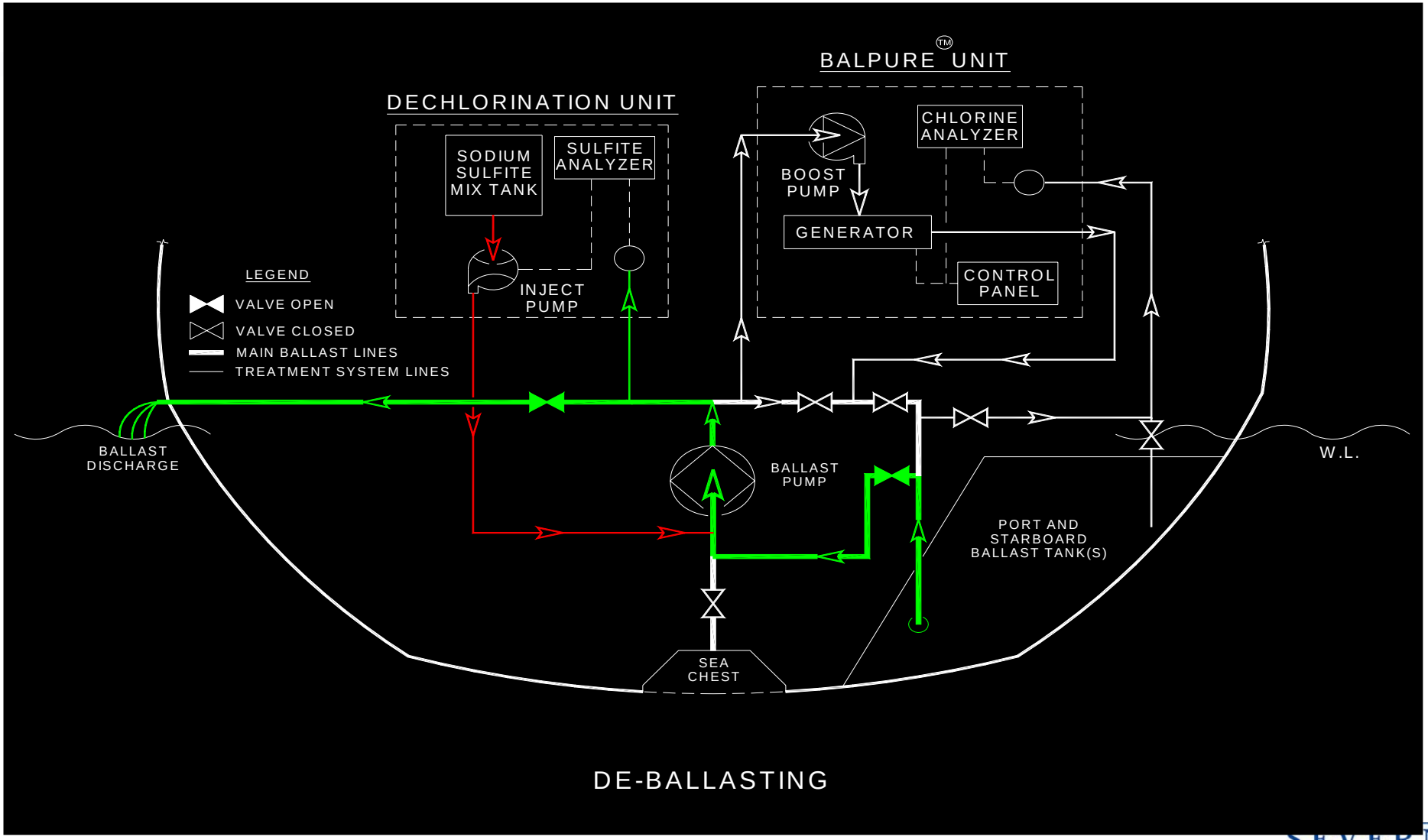


***Metered Dechlorination while Deballasting***

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# 1000 M3/Hr @ 5 ppm Unit

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# Electrolytic Ballast Water Treatment

## *1000 $M^3$ / Hr System*

| | Dimensions (inches) | Weight (pounds) |
|---|---|---|
| **Generator** | Height 46<br>Length 58<br>Width 15 | 550 |
| **Transform/Rectifier & Control Panel** | Height 65<br>Length 72<br>Width 36 | 3000 |
| **Overall** | Height 90<br>Length 144<br>Width 54 | 5900 |

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# Metering pumps are mounted on Skids complete w/ Local Disconnect, Sensors

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# Electrolytic Ballast Water Treatment

***Estimated Utilities for 1000 $M^3$ / Hr BWT Unit***

- Power
  - 52 AC KVA
- Process Water
  - None required
- Instrument Air
  - None required
- Sulfite for dechlorination
  - 2 Kg (4.4# or 1.3 gal.) per 1,000 $M^3$
- Maintenance
  - 4 hours per month

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# Electrolytic Ballast Water Treatment

***Conclusions***

- Meets IMO standards for Ballast Water Management
  - Destruction of living organisms
  - Bacteria inactivated
- De-chlorinated Effluent is not Toxic
- DBPs are below drinking water standards
- Filtration is not required to meet IMO standards
- Operating cost is less than $0.02 / M3 of ballast water

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